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(12) **APPLICATION OF PATENT OF INVENTION** A1

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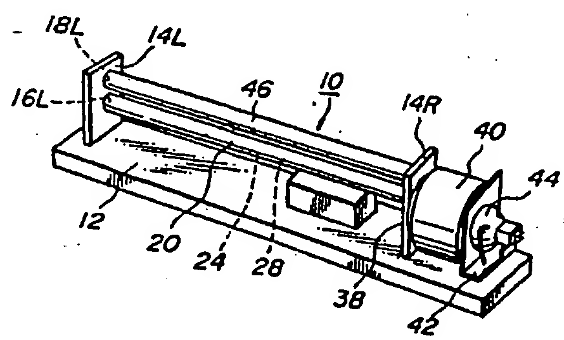
(54) **Light source device especially for administration or office machine**

(57) Abstract of the invention technical content.

A light guiding bar including a reflective mirror on one of its end surfaces, is mounted on base 12. A lamp 44 is mounted on the other end surface of the bar as a light source for emitting light into the light guiding bar. A fine powder with high refractive index is applied to the bar outer circumferential surface in the form of a straight band parallel to its axial direction in order to form a diffusion band.



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The present invention relates to a light source device, and more particularly to a light source device suitable for use as a light source in administration and office machines such as image readers, optical printers, monochromatic copiers, color copiers, fax machines, and others.

It is desirable to use as light source for administration and office machines such as image readers, optical printers, monochromatic copiers, color copiers, fax machines and others, those with which one can obtain a light with regular linear profile, uniform and non-polarizing energy. This light, which is also a radiating light, has a small distribution beam angle and almost parallel beams in order to improve the reading resolution and speed.

Until the present time, it was generally used for administration and office machines such as readers and the like, a light source device wherein tubular electrical bulb of the type dubbed two-end bulb, is placed inside a reflective mirror. A tubular electrical bulb is fixed in a pre-determined position after the focal point being adjusted inside said mirror.

With the above arrangement, when the power switch is on, the light emitted by the bulb is reflected by the mirror such that light radiates from the focal point placed in a pre-determined position.

In case of failure of one tubular electrical bulb due to its use, the bulb is

removed from the mirror and a new bulb is put again in this said pre-determined position after adjusting the focal point inside the reflective mirror.

However, due to the fact that such classical light source devices use two-end tubular electrical bulb, it was very difficult to obtain a light with regular linear profile, uniform and non-polarizing energy, and a light which is also a radiating light, has a small distribution beam angle and includes almost parallel beams.

In addition, the obtained device is too large due to the use of such tubular electrical bulb, such that it is difficult to use the device in a location where the space is insufficient. Moreover, due to the fact that it is necessary to maintain a comparatively long light emitting range, nominal voltage for the electrical bulb becomes a high voltage. It is then necessary to choose certain insulating materials in order to maintain favorable insulating conditions, and in parallel, there is a hazard in the handling of such electrical bulb. In addition, there is a fear of spending a lot of time for changing the electrical bulb due to the fact that the focal point must be adjusted again inside the reflective mirror when the tubular electrical bulb is changed.

Finally, classical light source devices using tubular electrical bulbs have low performance such that the energy consumption increases (usually about 200 watts to 500 watts), and the obtained radiated light contains infra-red beams, and the result is either a thermal deterioration of the device or the papers to be copied from, or a low performance of the condensation.

From a practical stand point, it is also very difficult to prepare a light source device functioning continuously with a two-end tubular electrical bulb.

Taking into consideration the above observation, document JAP-A-226571/83 was applied to the present invention to obtain a light source device allowing one to obtain a light with regular linear profile, uniform and non-polarizing energy; this light, which is also a radiating light, has a small distribution beam angle, the whole embodiment of which can be miniaturized, and the light emitting range of which can be increased with low voltage, wherein necessary working time to replace the electrical bulb can be reduced, and the energy consumption of which can be lowered by means of which infra-red beams can be removed from the radiating light and which can be continuously manufactured. In other words, the present invention focuses on the supply of a light source device comprising a base designed to be fixed to an apparatus, a light guiding bar mounted on said base and including a reflective mirror at one of its end surfaces, a diffusion band formed by applying a fine powder having high refractive index on the outer circumferential surface of said light guiding bar according to a fine straight band along the said bar axis, and a bulb mounted on the other end of said bar and emitting light into the other end of the said bar .

In the light source device according to the invention, the light penetrating through an end surface of said guiding bar, is reflected by the diffusion band such to be emitted in the direction opposite to the penetrating light, thanks to which a radiating light is produced.

In the light source device according to the invention, it is possible to obtain a desired distribution angle of the light beam of said light guiding bar on which the diffusion band was applied as well as a desired width of the light beam exiting from the light radiating to said surface of the light guiding source (below mentioned width of primary light beam on the surface of the light guiding bar), with an adjustment of the said guiding bar diameter and the diffusion band width. With respect to this, the distribution angle of the light beam is reduced with an increase of the light bar diameter due to a reduction of the diffusion band width. In addition, the exiting light beam width is almost the same as that of the band.

Other invention characteristics and advantages will appear during the description which follows, made with reference to attached drawings given uniquely as examples wherein:

Figure 1 is a perspective view showing the first invention embodiment;

Figure 2 is a side view of the embodiment in Figure 1;

Figure 3 is a perspective view showing the light guiding bar;

Figures 4A and 4B are perspective views, each showing one opposite end surface of a lighting sub-assembly;

Figure 4C is a cross-sectional view of Figures 4A and 4B;

Figures 4C and 4D are cross-sectional views, each showing another example of a lighting sub-assembly;

Figure 5 is a perspective view, showing a status wherein the reflector is fixed to a lighting sub-assembly;

Figures 6A and 6B are perspective views, each showing a status wherein the bulb is mounted on a socket;

Figure 7A is an explanatory diagram indicating the lens operating principle of a light guiding bar;

Figures 7B (a), (b) and (c) are explanatory diagrams, each showing a primary distribution angle and a secondary distribution angle;

Figure 8 is a diagram indicating measurement results of the distribution characteristics of light intensity represented by circular coordinates according to the light guiding bar direction;

Figure 9 is a diagram, showing luminance value with respect to the number of watts of an entering light source;

Figure 10 is a diagram indicating non-uniform characteristics of the light energy;

Figure 11A is a perspective view showing a second invention embodiment;

Figure 11B is a front view of the embodiment in Figure 11A;

Figures 12 and 13 are views, each showing another profile in the light guiding bar cross-section.

With reference made to drawings, Figures 1, 2, 3, 4A, 4B, 4C, 5, 6A and 6B illustrate an example of the invention wherein light source device 10 is mounted on an apparatus such as a reader or the like, by means of appropriate fixing element such as screws, bolts, and others. Support flanges 14L and 14R are vertically placed in opposition on base 12, holes 16L, 16R, 18L, 18R being pierced on support flanges 14L, 14R respectively in opposite positions in the vertical direction.

A lighting sub-assembly 20 is hung in rotation between holes 16L and 16R. This sub-assembly 20 is coated with a fine powder having high refractive index, this powder being applied to the outer circumferential surface of the light guiding bar 22 in order to transmit incident light from one bar end to the other according to a straight band in the bar axial direction to form diffusion band 24. Moreover, an end surface of sub-assembly 20 has a reflective mirror 26 fitted with a surface reflecting light to the inside of light guiding bar 22. Opposite ends of a cylindrical aluminum mirror 30 fitted with slot 28 placed in a position opposite to said diffusion band 24, are covered with supports 32 having a small interval 34. Thanks to it the outer circumferential surface of light guiding bar 22 is protected.

Bar 22 is solid and has a circular section. A material appropriate for bar 22 has, in all possible situations, a high transparency and a resistance favorable to the light, for example, silica glass in bar, optical glass in bar, silicone or acrylic resin in bar, or others can be used as materials for said bar.

Diffusion band 24 is made out with a fine powder having refractive index higher than that of bar 22 and a resistance favorable to the light; examples of such powder include barium sulfate, magnesium sulfate, titanium sulfate and others.

To apply the fine powder to light guiding bar 22 as band, it is possible to appropriately choose, for example, for powder liaison, a clear binder resistant to light such as a silicone resin wherein said fine powder is dispersed and included, using clear

adhesive silicone resins, or any other means.

From the end surface of light guiding bar 22 having no reflective mirror 26 which was not covered by the cylindrical mirror 30 fitted with a slot, the light is introduced inside said bar 22, with an incidence angle θ of about 30° with respect to optical axis; while the light being collected from a light source such as tungsten halogen lamp, mercury lamp, xenon lamp, flash lamp or others, it is transmitted in the axial direction with repetition of a complete reflection in bar 22. Transmitted light to said reflective mirror 26 is reflected by the latter. Due to the fact that diffusion band 24 formed with said fine powder having high refractive index, is formed on the outer circumferential surface of bar 22, according to its axial direction, this light transmitted across bar 22 and the light reflected by mirror 26, are subjected to a diffuse reflection in bar 22 by means of diffusion band 24. In addition, resulting light is emitted by the lens effect of said bar 22, in the opposite direction with respect to diffusion band 24. In Figure 3, arrows 200 show a light emitting direction. Figure 7A is an explanatory view showing the operating principle of the bar 22 lens, wherein diffusion band 24 acts as a reflective mirror with a circular diffusion arc which is closely in contact with the outer circumferential surface of bar 22.

As a consequence, primary light beam A with high light energy is formed by an exiting beam which is part of the diffused light, gathered on central axis 102 of bar 22, being diffused and reflected by the reflective mirror of diffusion band 24 according to

direction characterized by the arc of a circle form of this band, and by another constituent affecting a region superposing itself to an output beam which was already gathered on said central axis 102 which is part of the emitted light concentrated in the direction opposite to that of the diffusion band 24 due to decreasing angle of other diffused light which does not converge to central axis 102. Due to the light guiding bar 22 effect, these components are then synthesized and incorporated to form said beam A. Then, the secondary light beam B with lower light energy is composed of the constituent of the other diffused light, other than those forming said primary light beam A. Moreover, incident light which is not emitted by bar 22 is again completely reflected into the latter, and is diffused and reflected again by the diffusion band 24 to be emitted to the outside of bar 22. So, light transmitted and reflected in bar 22 is successively emitted by diffusion band 24 according to said diffusion band direction and in opposition to it on the side where diffusion band 24 was applied, during the transmission and reflection, such that it is possible to obtain a light with linear profile and uniform energy. In addition, due to the fact that lens effect of light guiding bar 22 varies as a function of the light wavelength, a component of the visible radiation has a distinct directivity while a component extending from the proximity of infra-red areas toward the infra-red areas hardly has a distinct directivity, such that this last component is diffused, thus allowing one to avoid harmful radiation of heat waves.

Consecutive to test performed by the applicant, it was confirmed that light emitted from light guiding bar 22, which was not covered by the cylindrical mirror 30 fitted with a

slot is dispersed into a primary light beam A with high light energy and useful as a light source in an administration or office machine and a secondary light beam B having low light energy as shown in Figure 7B (a), (b), (c) wherein:

Figure 7B (a),

Bar material:	Silica glass
Bar diameter:	6 mm
Bar length:	240 mm
Diffusion band material:	Fine titanium powder
Diffusion band width:	2 mm
Type of light source:	Tungsten halogen lamp
Primary beam angle:	about 37°
Secondary beam angle:	about 60°

Figure 7B (b),

Bar material:	Silica glass
Bar diameter:	10 mm
Bar length:	300 mm
Diffusion band material:	Fine titanium powder
Diffusion band width:	1.7 mm
Type of light source:	Tungsten halogen lamp
Primary beam angle:	about 17°
Secondary beam angle:	about 41°

Figure 7B (c),

Bar material:	Silica glass
Bar diameter:	10 mm
Bar length:	3000 mm
Diffusion band material:	Fine titanium powder
Diffusion band width:	2.8 mm
Type of light source:	Tungsten halogen lamp

Primary beam angle:	about 30°
Secondary beam angle:	about 53°

Measurement results of distribution characteristics of light intensity with respect to the light parallel to the direction of light guiding bar 22 axis (light emitted by bar 22) were obtained and represented by circular coordinates in Figure 8, wherein:

Bar material:	Silica glass
Bar diameter:	10 mm
Bar length:	240 mm
Diffusion band material:	Fine titanium powder
Diffusion band width:	2.8 mm
Type of light source:	Tungsten halogen lamp
Measured distance:	15 mm

In addition, Figure 9 is a graphic presentation indicating the luminance level with respect to the power in watts of the light energy, measured by means of a luminance measuring device, wherein:

Bar material:	Silica glass
Bar diameter:	10 mm
Bar length:	320 mm
Diffusion band material:	Fine titanium powder
Diffusion band width:	2.8 mm
Type of light source:	Tungsten halogen lamp

Moreover, from the measurement of the non-uniformity of primary light beam in light energy according to the light guiding bar 22 axis, it is possible to obtain a linear profile light having a very uniform light energy, as it is shown in Figure 10, wherein:

Bar material:	Silica glass
Bar diameter:	10 mm
Bar length:	320 mm
Diffusion band material:	Fine titanium powder
Diffusion band width:	2.8 mm
Type of light source:	Tungsten halogen lamp
Measured distance:	5 mm

Consecutive to tests illustrated in Figures 7B (a), (b), (c), it was found that the following formula can be established with regard to a relation between an exit angle of primary light beam a (simply designated thereafter as "primary beam angle") and an exit angle of the secondary light beam b (also simply designated thereafter as "secondary beam angle") of light guiding bar 22 which was not covered by the cylindrical mirror 30 fitted with a slot, and to which the diffusion band 24 was applied and a light guiding bar diameter:

- Primary light beam angle (degree) = 2 x $\sin^{-1}$ (diffusion band width / diameter of the light guiding bar cross-section).
- Secondary light beam angle (degree) = primary light beam angle + 23°.

The above means that it is possible to obtain almost parallel light beams having a small primary light beam angle with an increase of the light guiding bar diameter and a reduction of the diffusion band 24 width, while a desired primary light beam angle can be obtained in adjusting the light guiding bar 22 diameter and the diffusion band 24 width.

In addition, the width C of primary light beam issued from bar 22 (width of primary light beam on the bar 22 surface) was almost equal to the width of diffusion band 24.

Due to the fact that, from a practical stand point, it is desirable that the primary light beam angle is approximately 15°, it is advantageous to use a light guiding bar 22 having 10 mm diameter and a diffusion band 24 having 1.5 mm wide.

Although the width of slot 28 is almost the same as that of diffusion band 24, slot 28 is hardly larger than diffusion band 24, thanks to it, the secondary light beam is reflected to the inside of bar 22 by means of cylindrical mirror 30 fitted with a slot to return to the diffusion band 24. Returned light beam is used again as primary light beam to only transmit a primary light beam useful as a light source for an administration or office machine.

For support 32, it is possible to use any material having light resistance and appropriate degree of mechanical resistance such as fluoroplastic material.

Reflector 38 is fixed to the bar 22 outer surface opposite to that comprising reflective mirror 26, this reflector 38 having a reflective surface for sending back a dispersed light beam other than the efficient incident light in directing it by means of bar 22 toward the reflective mirror of lamp 44. A socket of lamp 40 is placed on reflector 38, and a lamp socket 42 is mounted on this fixture 40, thanks to which lamp 44 is removably held by means of an elastic element of lamp 42 support for holding the lamp. It is possible to use, as lamp 44, a tungsten halogen lamp, a xenon lamp, a flash lamp, and other, and in the present example, a tungsten halogen lamp is used with a reflective mirror.

In addition, lens 46, made up with a bar, is hung between holes 18L and 18R

located above holes 16L and 16R, used as a condenser for condensing primary light beam A emitted by bar 22 in the event that diffusion band 24 is placed lower and the slot 28 in a higher position. Of course, it is possible to use as a condenser a cylindrical lens, a reflective mirror,or others in lieu of a lens made up with a bar.

In the above construction, when the bulb 44 is lit, light issued by this bulb penetrates into the end surface of bar 22 either directly, or through reflector 38 while making this light converging. Only the primary light beam A of the incident light penetrates into lens 46 by means of diffusion band 24 through slot 28, primary light beam A being, in addition, condensed by the bar forming lens 46, after that this light is radiated in the form of uniform linear light having a regular light energy and formed with almost parallel beams.

Secondary light beam B is reflected by the cylindrical mirror 26 fitted with a slot in order to reach the diffusion band 24 in bar 22. Thanks to it, resulting light is again used as primary light beam.

To change the radiation direction of the primary light beam A, it is enough to rotate the sub-assembly 20 of the lamp.

To replace lamp 44, elastic element of lamp support 42 is liberated to release lamp 44 and it is possible to put in again a new lamp by means of the elastic element of support 42.

Figures 11A and 11B illustrate a second invention embodiment wherein a condenser is used as reflector, and wherein similar elements designated by the same reference numbers as those in the first embodiment in different views, such that a new

description of these elements is eliminated. In a light source device 100, light guiding bar 22 is hung between support flanges 114L and 114R vertically placed in opposition on base 110. Inner surface of base 110 forms a reflective mirror 112 having a quadratic cross-section surface.

In the above construction, light issued from light guiding bar 22 is condensed by means of reflective mirror 112 to radiate to a pre-determined position.

Moreover, Figures 4D and 4E show other examples of sub-assembly 20 wherein each light guide 36a and 36b is a board made out with glass, acrylic resin or others, and is fixed in the slot 28.

Primary light beam emitted by light guiding bar 22 can be guided to a pre-determined position by means of these light guides 36a and 36b such that primary light direction could be arbitrarily controlled, thanks to it, it becomes possible to emit primary light beam from a pre-determined position.

In these examples, of course, it is not necessary to cover bar 22 with a cylindrical mirror 30 fitted with a slot, nor to provide lens 36 formed with a bar, a reflective mirror 112 or the like acting as condenser.

Moreover, bar 22 cross-section is not limited of a circular form, but it is possible to appropriately choose an almost circular cross-section whose flat portion is intended for receiving diffusion band 24, a cross-section having quadratic surface such as an elliptic cross-section and others as shown in Figures 12 and 13.

The way to introduce the light issued from lamp 44 into bar 22 is not limited to the one described in the present embodiment, but it is possible, of course, to use a quartz rod or other to connect lamp 44 to optical fiber bar 22, in order to guide the light from lamp 44 across said fiber optic, quartz rod or other. In this example, light can easily be introduced even if the lamp and the bar form an angle, or even if their positions are moved.

As it was described above, the set of light source, according to the invention, includes a base intended to be fixed to an apparatus, a light guiding bar supported by said base and fitted with a reflective mirror at one of its end surfaces, a diffusion band formed by applying a fine powder having high refractive index to the outer circumferential surface of said light guiding bar to form a straight band along the bar axis and a lamp mounted on the other end of said bar and emitting light into said other end of the bar. So, according to the invention, it is possible to obtain a radiating light with regular linear profile, uniform and non-polarizing energy, i.e. a light having small distribution beam angle, and formed with almost parallel beams, and in the same time the whole device construction can be miniaturized, and the transmission light range can be increased with low voltage. Moreover, it is possible to save time when replacing the lamp.

Furthermore, due to the fact that light source device according to the invention does not use a tubular electrical bulb, it is possible to improve its radiation performance, to reduce the energy consumption in the device and to eliminate infra-red light or near infra-red light in radiated beam, while making, in the same time, a light source with desired length.

CLAIMS

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1. Light source device characterized by the fact that it includes a base (12) intended to be fixed to an apparatus, a light guiding bar (22) fixed on said base and fitted with a reflective mirror (26) at one of its end surfaces, a diffusion band (24) formed with the application of a fine powder having high refractive index to the outer circumferential surface of said light guiding bar (22) in the form of a straight band parallel to the axial direction, and a lamp (44) mounted on the other end of said bar (22) and transmitting light into said other end of this bar.

2. Light source device according to claim 1, characterized by the fact that said light guiding bar (22) is mounted in rotation on said base (12).

3. Light source device according to claim 1 or 2, characterized by the fact that said light guiding bar (22) is covered with a cylindrical mirror (30) fitted with slot (28) formed at the opposite side of said diffusion band (24).

4. Light source device according to claim 1, wherein a light guide is introduced into the slot (28) of said cylindrical mirror (30).

5. Light source device characterized by the fact that it includes a base (12) intended to be fixed to an apparatus, a light guiding bar (22) fixed to said base (12) and fitted with a reflective mirror (26) at one of its end surfaces, a diffusion band (24) formed with the application of a fine powder having high refractive index to the outer circumferential surface of said light guiding bar (22), in the form of a straight band parallel to the axial direction, a lamp (44) mounted at the other end of said light guiding bar (22) and transmitting light to said other end of the bar, and a condenser (46) for condensing light

emitted by said light guiding bar.

6. Light source device according to claim 5, characterized by the fact that said light guiding bar (22) is mounted in rotation on said base (12).

7, Light source device according to claim 5 or 6, characterized by the fact that said light guiding bar (22) is covered with a cylindrical mirror (30) fitted with slot (28) delimited at the opposite side of said diffusion band (24).

Light source device according to claim 7, characterized by the fact that a light guide (36a, 36b) is introduced into the slot of said cylindrical mirror.

Translated by Henry D. Mai
Member of A.T.A.
November 1998
651-774-0601

FIG. 1

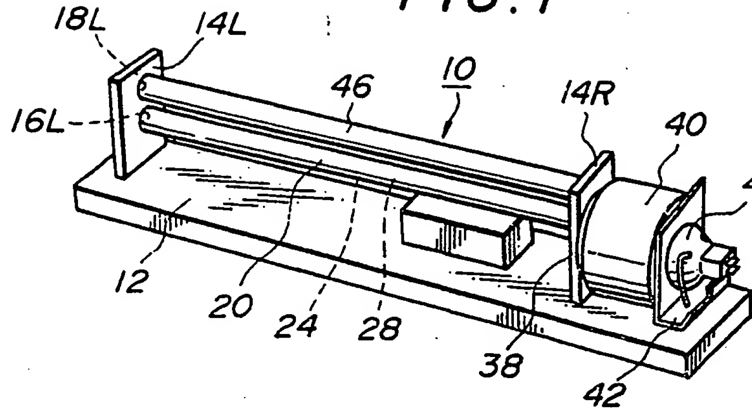


FIG. 2

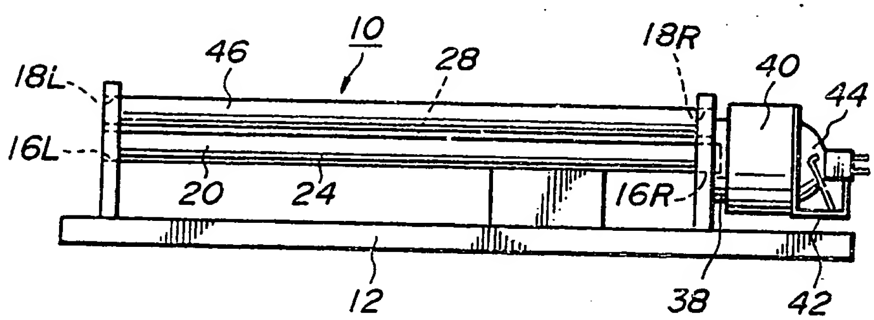


FIG. 3

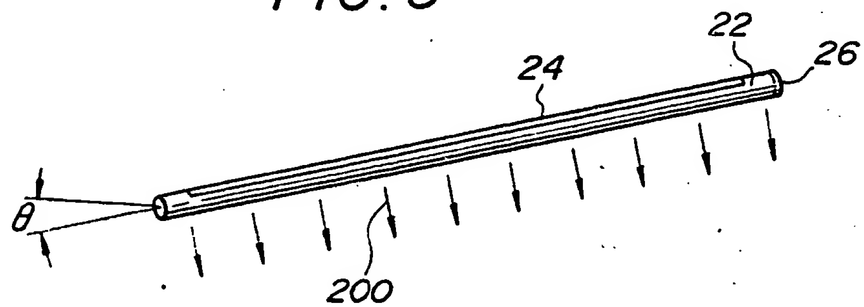


FIG. 4A

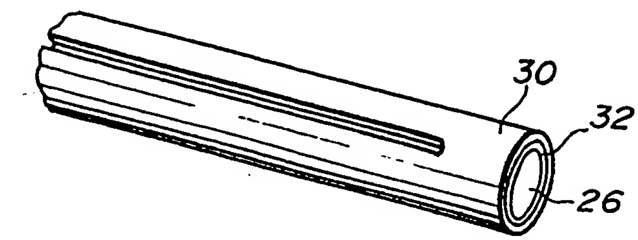


FIG. 4B

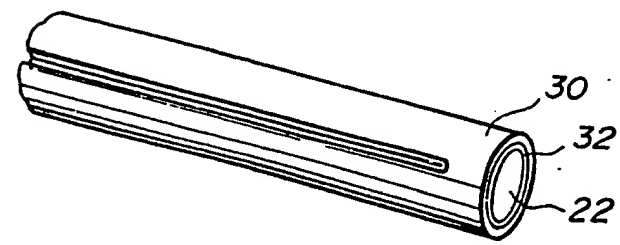


FIG. 4C

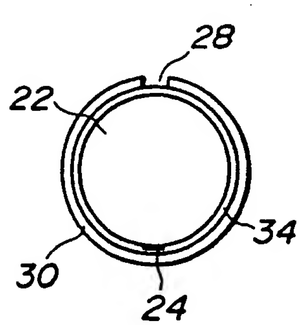


FIG. 4D

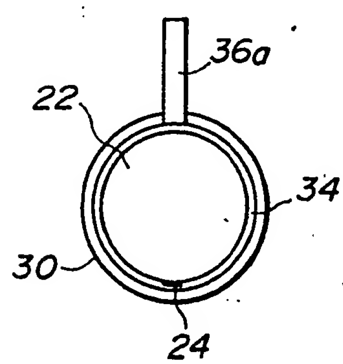


FIG. 4E

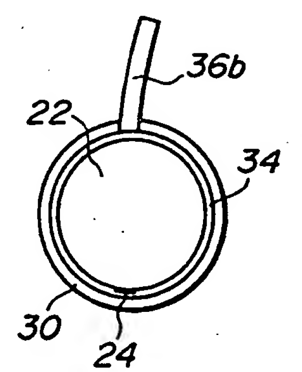


FIG. 5

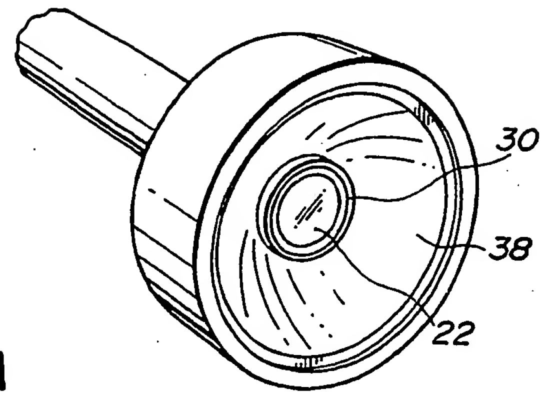


FIG. 6A

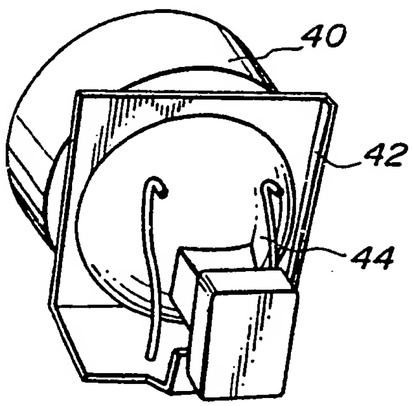


FIG. 6B

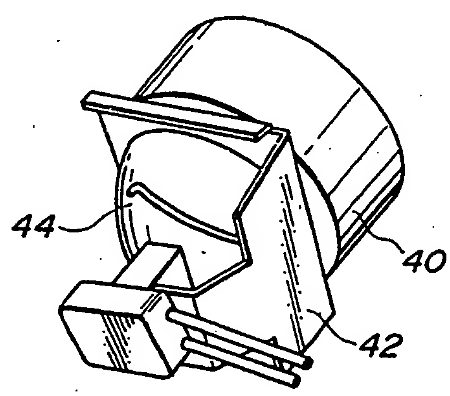
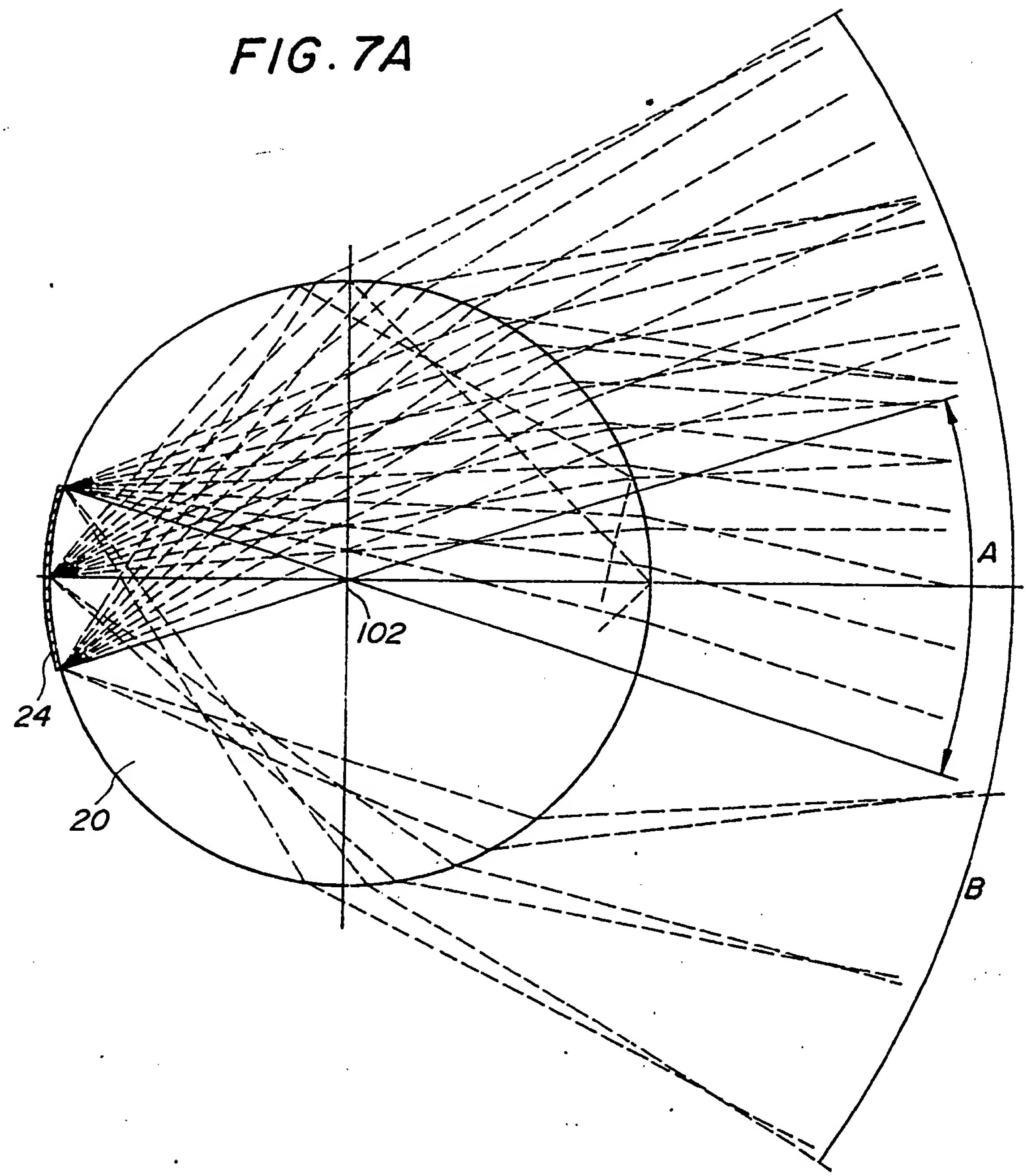


FIG. 7A



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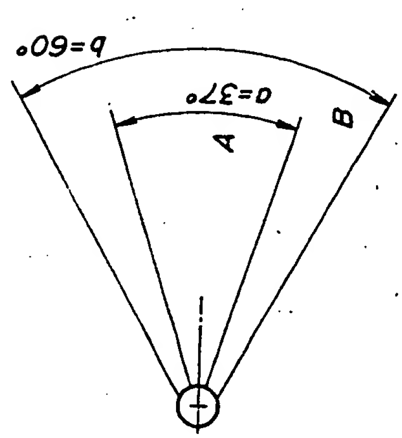

FIG.7B(a)

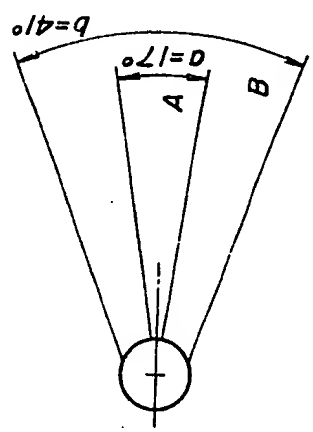

FIG. 7B(b)

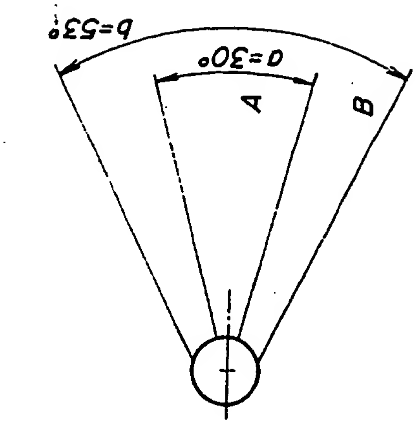

FIG.7B(c)

FIG. 8

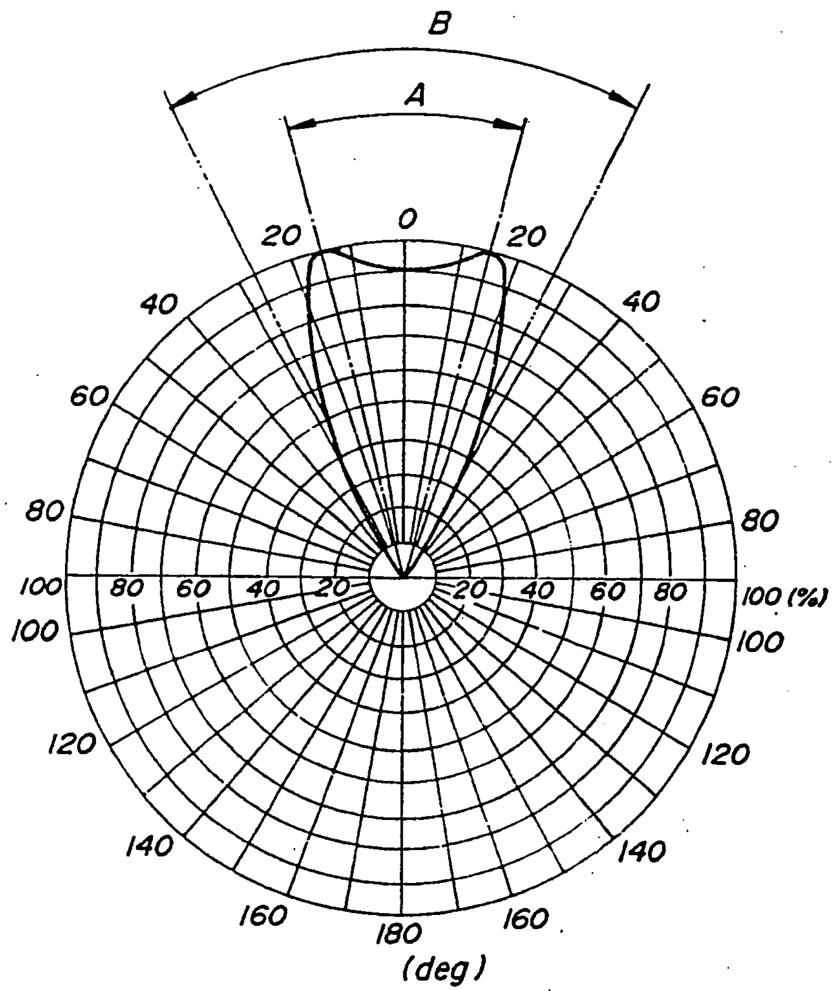

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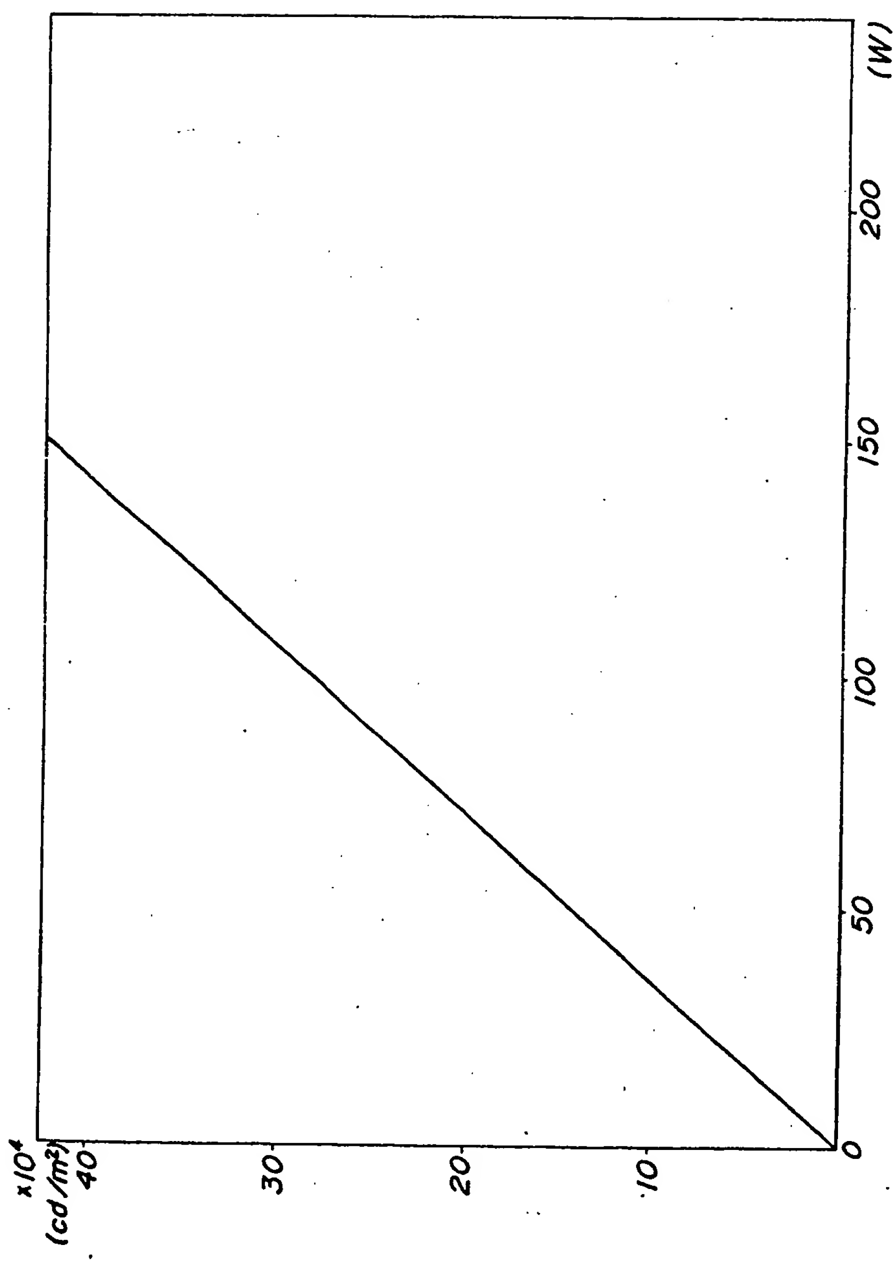
FIG. 9



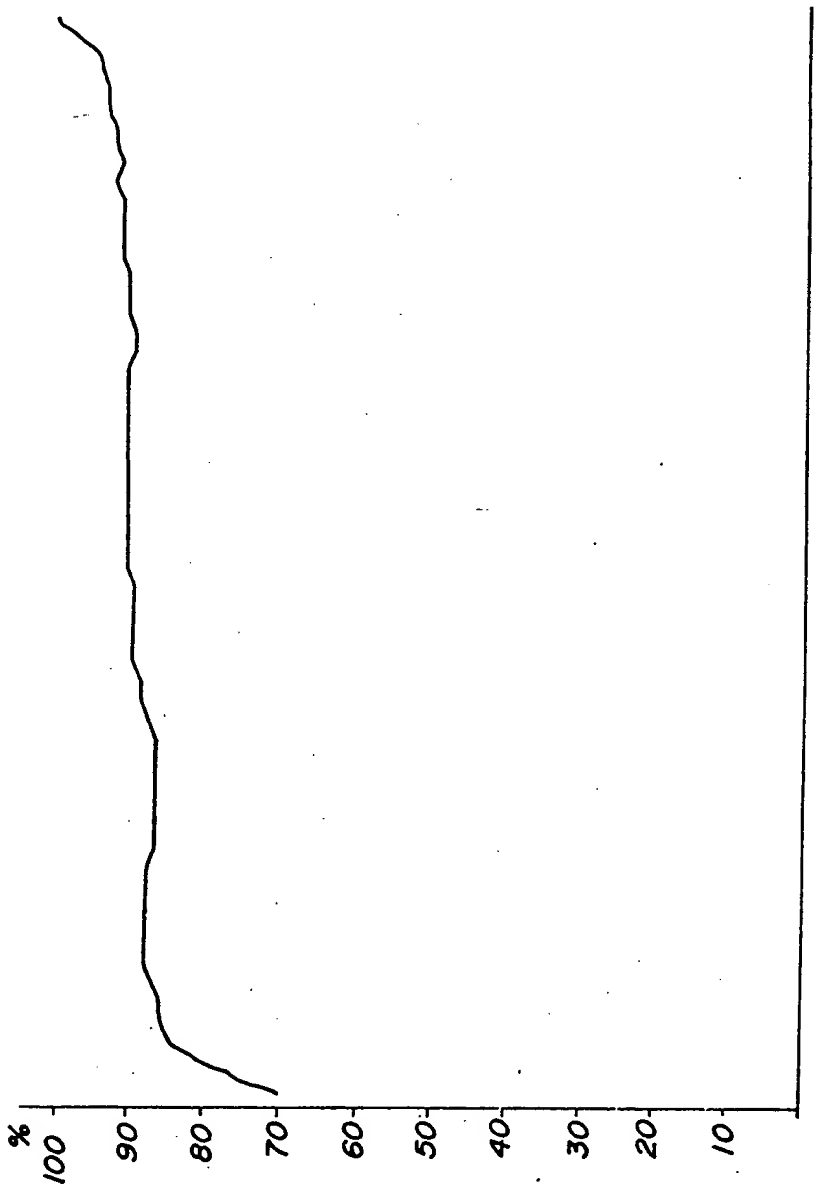


FIG. 10

FIG. 11A

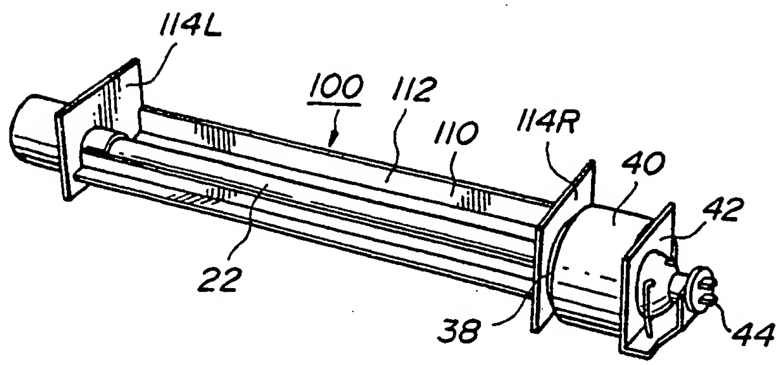


FIG. 11B

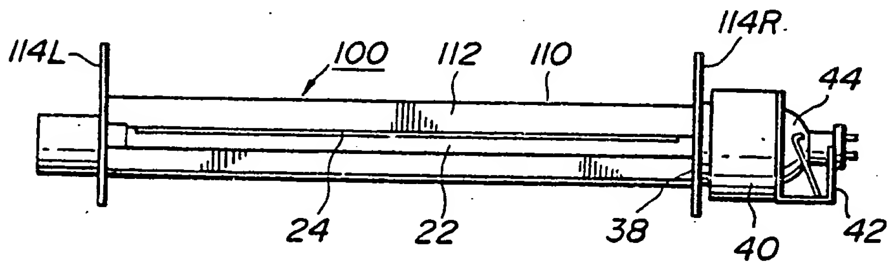


FIG. 12

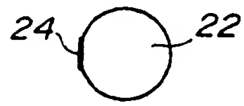


FIG. 13